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Description of a new species of leopard geckos, *Eublepharis* Gray, 1827 from Eastern Ghats, India with notes on *Eublepharis hardwickii* Gray, 1827

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Abstract

A recent molecular phylogenetic study of the genus *Eublepharis* Gray, 1827 revealed the presence of a genetically divergent lineage sister to *Eublepharis hardwickii* Gray, 1827. We re-assessed the taxonomy of *Eublepharis hardwickii* based on museum material in light of the molecular phylogenetic study and the results support the recognization of two species distributed on either sides of the Brahmani River. A redescription of *E. hardwickii* is presented based on the holotype and additional museum material along-with the description of a new species, *Eublepharis pictus* **sp. nov.** from Andhra Pradesh and Odisha. The presence of yet another distinct lineage in such close geographical proximity in the northern Eastern Ghats highlights the significance of these relic forests and advocates the need for conservation prioritization.

Key Words

Biodiversity, conservation, Eastern Ghats, leopard gecko, Sauria, Taxonomy

Introduction

The lizard family Eublepharidae currently contains 44 species in six genera distributed in parts of North and Central America, West and East Africa, Middle East, South Asia and the Malayan Archipelago (Smith 1935, Grismer 1988, Uetz and Hošek 2021). The family spans from tropical to temperate latitudes exhibiting a remarkable intercontinental disjunct distribution (Grismer 1988, Agarwal et al. 2022). The family is less diverse compared to other gekkotan lizard families (Grismer et al. 2021, Pal et al. 2021) and is relatively poorly studied in their natural habitats, especially members of the genus *Eublepharis* (Grismer 1988, Mirza and Upadhye 2010, Mirza et al. 2014, Agarwal et al. 2022). The genus *Eublepharis* is represented by six species of which four are recorded from India (Mirza et al. 2014, Agarwal et al. 2022) and is the least attended genus in terms of its taxonomy with few exceptions (Börner 1974, 1981, Das 1997, Mirza et al. 2014). In addition to this, three genetically distinct lineages have been identified in a recent phylogenetic assessment of the genus (Agarwal et al. 2022). One of these three lineages is related to *Eublepharis hardwickii*, a species distributed in northern Eastern Ghats and parts of Jharkhand and southern West Bengal (Smith 1935, Mirza et al. 2014). Gray (1827) described the species and stated that the specimen originated from Chittagong (Bangladesh), which, likely is an error as the species has never since been recorded from Bangladesh. Thereafter the species was recorded from several places in West Bengal, Jharkhand, Odisha and Andhra Pradesh (Tikader and Sharma 1992, Daniel 2002, Murthy and Aengals 2008).

A reappraisal of existing museum material in light of the recent phylogeny of the genus *Eublepharis* (Agarwal et al. 2022) allows us to assess the systematics of *Eublepharis hardwickii*. The presence of two genetically

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distinct lineages within the *E. hardwickii* group advocates the need for a taxonomic intervention. The type of the species is here redescribed and diagnosed and represents the northern population, allowing the description of the southern population as a new species.

Materials and methods

Fieldwork and sampling

A recently dead female of the new species was found in a water tank in Vishakhapatnam, Andhra Pradesh. It was collected, washed, fixed in 4% formaldehyde for two days and later transferred to 70% ethanol and deposited in the collection of the National Centre for Biological Sciences, Bangalore.

Morphology and morphometry

All measurements were taken following Mirza and Sanap (2014) with Mitutoyo digital calipers (Mitutoyo Corporation, Kawasaki, Japan) (to the nearest 0.1 mm): snout-vent length (**SVL**: from tip of snout to vent), trunk length (**TRL**: distance from axilla to groin measured from posterior edge of forelimb insertion to anterior edge of hind limb insertion), body width (**BW**: maximum width of body), crus length (**CL**: from base of heel to knee); tail length (**TL**: from vent to tip of tail), tail width (**TW**: measured at widest point of tail); head length (**HL**: distance between retroarticular process of jaw and snout-tip), head width (**HW**: maximum width of head), head height (**HH**: maximum height of head, from occiput to underside of jaws), forearm length (**FL**: from base of palm to elbow); ear length (**EL**: longest dimension of ear); orbital diameter (**OD**: greatest diameter of orbit), nares to eye distance (**NE**: distance between anteriormost point of eye and nostril), snout to eye distance (**SE**: distance between anteriormost point of eye and tip of snout), eye to ear distance (**EE**: distance from anterior edge of ear opening to posterior margin of eye), internarial distance (**IN**: distance between nares), interorbital distance (**IO**: shortest distance between left and right supraciliary scale rows), Dorsal longitudinal tubercle rows (DTR) were counted from across the dorsum of the trunk, ventral scales across the belly (VS), post cloacal spurs (PCS) (Table 2). Meristic counts and external observations of morphology were made using a Leica™ S8APO (Leica Camera, Wetzlar, Germany) dissecting microscope. Images of the specimens were taken with a Canon™ 70D mounted with a Canon™ 100 mm macro illuminated with two external Canon™ 430EX-II flashes (Canon Inc., Tokyo, Japan). LISD for the publication: urn:lsid:zoobank.org:pub:C-82B30EE-83F7-4172-802D-3C36AB1BCC4E.

Molecular analysis

Sequence data for NADH dehydrogenase subunit 2 (ND2) was acquired form Agarwal et al. (2022) listed in Table 1. The sequences were aligned with CLUSTALW (Thompson et al. 1994) with default parameters in MegaX (Kumar et al. 2018). The aligned dataset was subjected to Maximum Likelihood phylogeny on the IQ-TREE online portal (Minh et al. 2020). The data was partitioned based on codon positions, and model selection was chosen on an auto parameter (Kalyaanamoorthy et al. 2017). The analysis was executed with TN+F+I (first codon position), HKY+F+G4 (second codon position) & TN+F+G4 (third codon position) model for sequence substitution with an ultra-fast search method with 1000 iterations. Genetic sequence divergence (p-distance) was calculated in MegaX with partial deletion of missing data.

Table 1. Accession numbers for sequences used in the present study.

Species	Locality	Accession number
Eublepharis angramainyu	Iran, Khuzestan	OK563653
Eublepharis angramainyu	Iran, Khuzestan	OK563654
Eublepharis angramainyu	Iran, Ilam	OK563655
Eublepharis angramainyu	Iran, Masjed Soleyman	OK563656
Eublepharis angramainyu	Iran, Kermanshah	OK563657
Eublepharis angramainyu	Iran, Ilam	OK563658
Eublepharis angramainyu	Iran, Ilam	OK563659
Eublepharis angramainyu	Iran, Kermanshah	OK563660
Eublepharis angramainyu	Iran, Khuzestan Province	OK563661
Eublepharis angramainyu	Iran, Khuzestan Province	OK563662
Eublepharis angramainyu	Iran, Masjed Soleyman	OK563663
Eublepharis fuscus	India, Gujarat, Kutch	OK563664
Eublepharis fuscus	India, Maharashtra, Aurangabad	OK563665
Eublepharis fuscus	India, Maharashtra, Dhule	OK563666
Eublepharis fuscus	India, Gujarat, Kutch	OK563667
Eublepharis fuscus	India, Maharashtra, Pune	OK563668
Eublepharis fuscus	India, Maharashtra, Dhule	OK563669
Eublepharis fuscus	India, Maharashtra, Aurangabad	OK563670
Eublepharis hardwickii	India, Odisha, Balasore	OK563672
Eublepharis hardwickii	India, Odisha, Balasore	OK563673
Eublepharis pictus	India, Odisha, Kandhamal	OK563674
Eublepharis pictus	India, Odisha, Kapilash	OK563675
Eublepharis pictus	India, Andhra Pradesh, Visakhapatnam	OK563676
Eublepharis pictus	India, Odisha, Angul	OK563677
Eublepharis pictus	NA	OK563678
Eublepharis macularius	Pakistan, Khyber, Pakhtunkhwa, Buner	OK563679
Eublepharis macularius	Pakistan, Khyber, Pakhtunkhwa, Buner	OK563680
Eublepharis macularius	Pakistan, Sindh, Dadu	OK563685
Eublepharis sp. Himalaya	German line	OK563705
Eublepharis sp. Himalaya	female, Germany bloodline	OK563706
Eublepharis sp. Pakistan	Pakistan, Khyber, Pakhtunkhwa, Bajaur	OK563707
Eublepharis sp. Pakistan	Pakistan, Khyber, Pakhtunkhwa, Bajaur	OK563708
Eublepharis sp. Pakistan	Pakistan, Khyber, Pakhtunkhwa, Bajaur	OK563709
Eublepharis cf. *smithii*	India, Rajasthan, near Dholpur	OK563712
Eublepharis cf. *smithii*	India, Rajasthan, ~25 km NW Pilani	OK563713
Eublepharis satpuraensis	India, Maharashtra, Chikhaldhara	OK563698
Eublepharis satpuraensis	India, Madhya Pradesh, Nr. Ashapuri	OK563700
Eublepharis satpuraensis	India, Madhya Pradesh, Pachmarhi	OK563701
Hemitheconyx caudicinctus		JX041370
Holodactylus africanus	Kajiado District, Kenya	JX041372

Results

Molecular results

ML phylogeny inferred on 1041 bp of mitochondrial ND2 gene recovered comparable results as Agarwal et al. (2022) with slight discrepancies. According to our results, *E. angramainyu* is sister to all other *Eublepharis*, and the *E. hardwickii* group is sister to the *E. macularius* clade (containing *E. macularius*, *E. fuscus*, *E. satpuraensis*, *E.* sp. Himalayas, *E.* cf. *smithii*, *E.* sp. Pakistan). The relationships within the *E. macularius* clade have poor to moderate support. The *E. hardwickii* group shows two distinct well-supported clades corresponding to the population from north and south. The northern population represents *E. hardwickii sensu stricto* (Agarwal et al. 2022) and the southern population represents an un-named taxon which is here described as *E. pictus* sp. nov. (Fig. 1). The new species differs from *E. hardwickii sensu stricto* in showing an uncorrected pairwise sequence divergence of 8–9% for mitochondrial ND2 gene.

Systematics

Gray (1827) described *Eublepharis hardwickii* based on a single specimen, which originated in Chittagong (now in Bangladesh). The locality is likely erroneous (Das 1997, Agarwal et al. 2022) and could have been mixed with samples originating from Chittagong, as the species has not been reported from the locality since then. Smith (1935) attributed the name *Gymnodactylus lunatus* to Blyth in Cantor (1847). There was no description of this nomen thereafter in literature until 1854 (Blyth 1854) in the Journal of the Asiatic Society of Bengal, which cites the journal's XVI page 633 for the description. However, the page does not carry any description of this nomen and was subsequently regarded as a nomen nudum (Das et al. 1998) and is not available. Regardless of this, the type

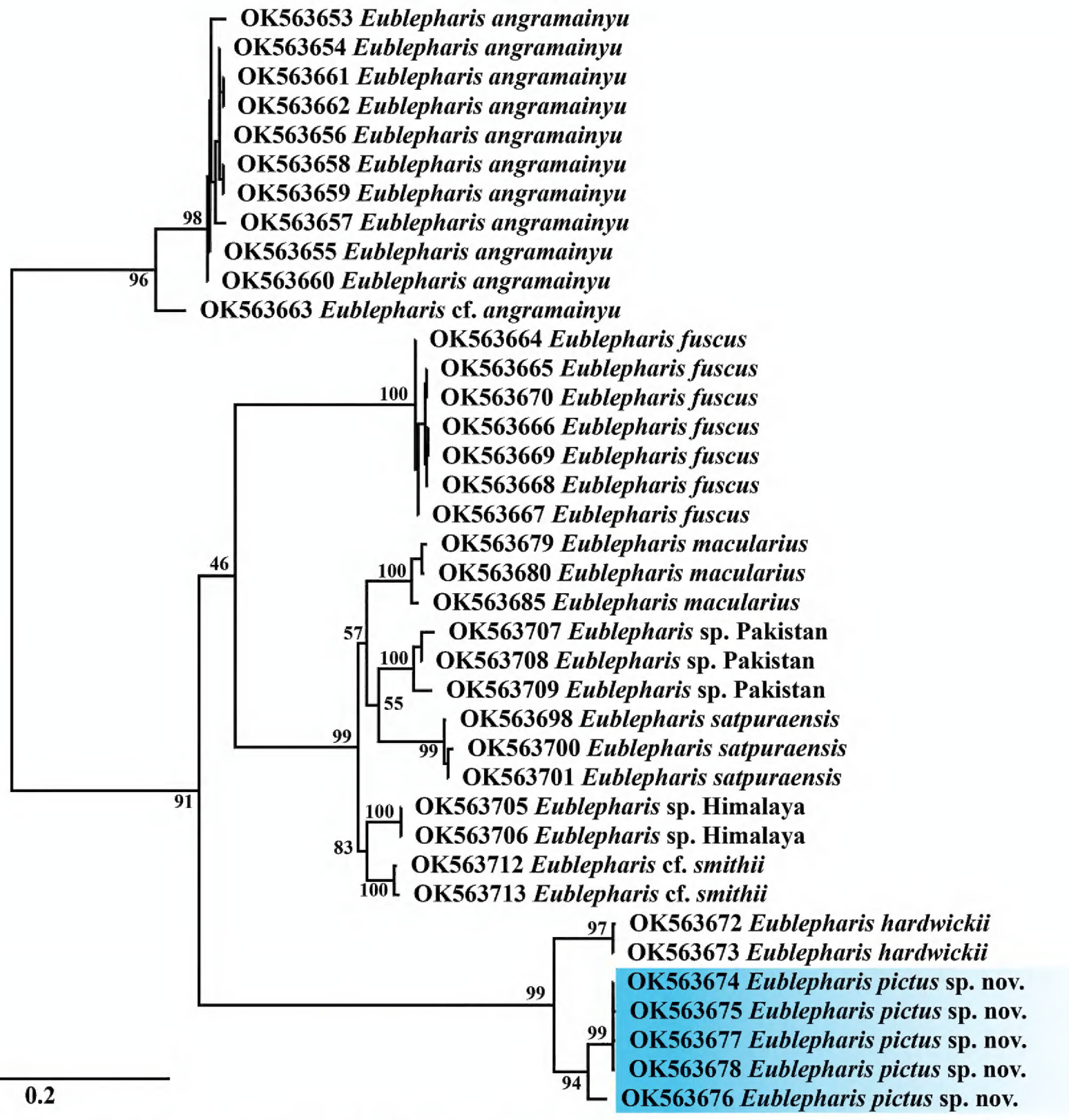

Figure 1. ML phylogeny inferred from mitochondrial ND3 gene for members of the genus *Eublepharis* spp. The clade in a shade of blue highlights the new species, *E. pictus* sp. nov.

specimens of *Gymnodactylus lunatus* originated from Midnapore (West Bengal) and Chyebassa (now Chaibasa, Jharkhand). These localities lie within the distribution range of *E. hardwickii sensu stricto* and thereby synonymous. Thus, the southern population does not bear a name and is herein described as a new species. For morphological details see below.

Eublepharis hardwickii Gray, 1827

Figs 2, 6; Table 2

Eublepharis hardwickii Günther 1864: 119 (in part); Boulenger 1885: 231 (in part); Boulenger 1890: 107 (in part); Smith 1935: 126 (in part); Grismer 1988:465; Mirza et al. 2014: 90

Gymnodactylus lunatus Blyth, 1847 *nomen nudum*

Holotype. Adult male NHMUK 1946.8.26.67 from Chittagong (The specimen is regarded as a holotype by the virtue of monotypy and recommendations of the code Article 73 and provision 73.1.2.) (International Commission on Zoological Nomenclature 1999).

Referred material. male BNHS 855, Barajamda, Singbhum, Jharkhand, India; juvenile NHMUK 1927.8.9.1 Dhalbhum, Chota Nagpur, India.

Diagnosis. A medium sized *Eublepharis* reaching SVL of 140 mm, with 24 rows of flat, tubercle-like moderately keeled scales across the dorsum intermixed with much smaller scales, a single pale band between the nuchal loop and caudal constriction; smooth subdigital lamellae on digit IV of pes 17; 16 precloacal pores in an angulate series lacking a diastema.

Etymology. The specific epithet is a patronym honoring Major-General Thomas Hardwicke (1756–1835) of the Bengal army of the East India Company.

Description of holotype NHMUK 1946.8.26.6. (Fig. 2): the type is in good condition of preservation, it is preserved in a linear 'S' shaped manner. The anterior interocular region bears a deep grove, which may be an artifact of preservation or an injury.

A large sized gecko (SVL 140 mm) with a fairly large head (HL/SVL ratio 0.14), head as long as wide (HW/HL ratio 0.99), head depressed (HH/HL ratio 0.58), distinct from neck (Fig. 2a, b); canthus rostralis inflated; snout short (SE/HW ratio 0.48), obtusely pointed from dorsal view and acutely in lateral view (Fig. 2c); longer than eye diameter (OD/SE ratio 0.51); scales on the snout heterogenous in shape and size, smaller ones with rounded edges and larger ones sub-hexagonal, convex; size of the scales increases in size towards the temporal region and are more flat intermixed with small rounded smooth scales. The scales post the temporal region are large, tubercle-like and sub-conical. These scales cover the dorsum of the animal, the hind limbs up-until the caudal constriction; eyes large (OD/HL ratio 0.25), pupil vertical with crenulated edges; supraciliaries 22, anterior ones smaller, these gradually increase in size and turn sub-conical from rounded towards the posterior portion; ear-opening large, sub-oval, obliquely oriented, smaller than orbital diameter (EL/OD ratio 0.77) lobules absent; eye to ear distance much greater than diameter of eye (EE/OD ratio 1.99); rostral quadrangle, much wider than deep, divided by a median suture for its entire length; rostral in contact with nasal, first supralabial and internasals; two large and a slightly smaller internasal between nasals, nostrils large situated medially in the nasal scale; mental sub-quadrangular, wider than long; (Fig. 4b); scales bordering the mental and infralabials large, gradually these reduce in size on throat up till the upper thoracic region, overall these scales are circular, convex, smaller than the ones ventral aspect of trunk; supralabials eleven on left and nine on right side; supralabials (to angle of jaw) twelve on either side; infralabials (to angle of jaw) nine on either sides.

Body elongate (TRL/SVL ratio 0.33) and dorsoventrally flattened; lacking distinct ventrolateral furrow; dorsal scalation on trunk comprises of large sub-conical scales intermixed with small, round-edged flat scales, the large sub-conical scales are fairly arranged in 24 longitudinal rows at mid-body; ventral scales on trunk smooth, flat, smaller than dorsal scales; mid body scales across belly 26; a continuous series of 16 precloacal pores; (Fig. 2b).

Limbs short, stout; digits bearing horizontally oriented smooth, un-notched lamellae on ventral surface; clawed, claw slightly smaller than length of the lamellar region; forelimbs short (FL/SVL ratio 0.09), equal in length with the hind limbs (CL/SVL ratio 0.10). Terminal phalanx of all digits curved, arising angularly from distal portion

Table 2. Morphological and merestic data for *E. hardwickii* and *E. pictus* sp. nov. All measurements in mm.

	E. hardwickii	*E. pictus* sp. nov.	*E. pictus* sp. nov.
	Holotype	**Holotype**	**Paratype**
	NHMUK 1946.8.26.6	**NCBS NRC-AA-0015**	**NHMUK 1962.238**
Sex	male	female	male
SVL	140.0	117.0	103.7
TRL	46.0	55.5	38.0
CL	14.3	16.8	18.8
TL	94.0	89.0	54.6
TW	9.0	5.3	10.0
HL	19.6	17.4	24.3
HW	19.3	19.8	20.9
HH	11.3	11.3	13.9
FL	13.5	16.0	15.8
EL	3.7	3.5	3.3
OD	4.8	6.8	4.7
NE	7.4	7.7	7.3
SE	9.4	10.3	11.2
EE	9.6	9.3	11.6
IN	4.0	3.8	3.9
IO	7.7	6.8	7.9
Pores	15	-	18
Supralabials	11 & 9	10 & 10	10 & 10
Infralabials	11 & 11	11 & 10	10 & 10
DTR	24	23	26
VS	26–28	24	24–26
PCS	2	2	2
Lamellae right manus	8-12-13-14-12	7-14-14-15-12	-
Lamellae right pes	8-13-15-17-16	8-16-15-19-16	-

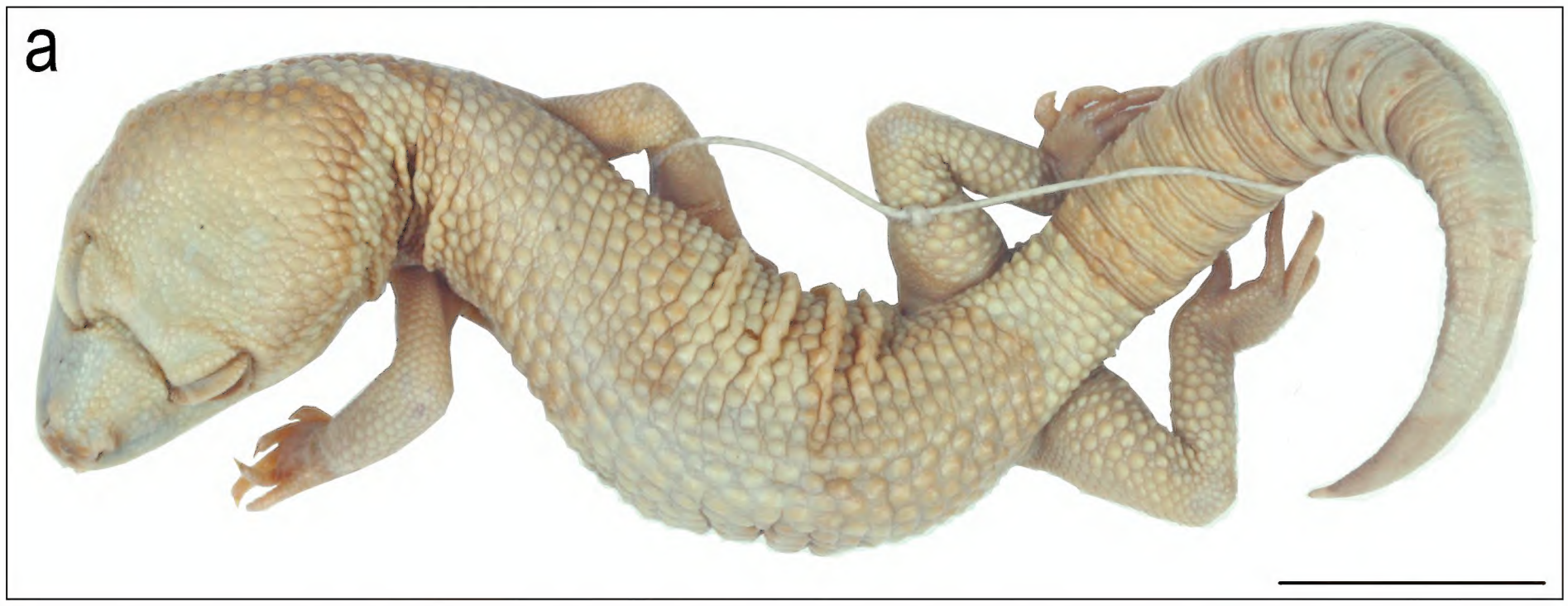

Figure 2. *Eublepharis hardwickii* holotype male NHMUK 1946.8.26.67 **a.** Dorsal view; **b.** Ventral view; **c.** Head dorsal view; **d.** Head ventral view; **e.** Lateral view. Scale bars: 20 mm.

of expanded lamellar pad, free portion of phalanx of all digits half to more than half long as the dilated portion. Lamellae beneath the digits, right manus 8-12-13-14-12; right pes 8-13-15-17-16. Relative lengths of digits: III>V>IV>II>I (left manus), V>II>IV>III>I (left pes).

Tail stout, subtly flat on its ventral aspect, round in cross section, longer than snout-vent length (TL/SVL ratio 0.67). Caudal segments distinct on original tail; pholidosis of original tail dorsum with small, juxtaposed scales intermixed with large sub-conical tubercles in a

whorl or 9–10 rows on the first segment, thereafter reduces in number on subsequent segments, scales on regenerated portion of tail heterogenous, lacking tubercles. Ventral aspect with large, broad scales, median row of scales not enlarged. Two sub-conical post cloacal spurs.

Distribution and natural history (Fig. 5). The northernmost range of the species appears to be Aushgram in Burdwan district (West Bengal) is the northern most record of the species (Chandra et al. 1997) and other records are from Chaibasa (Cantor 1847, Smith 1935) and BNHS 855 Barajamda (Jharkhand) Belpahari (West Bengal) (Samanta et al. 2021) and Similipal (Dutta et al. 2009) and Balasore (Odisha) (Agarwal et al. 2022) is the southernmost record of the species. Nothing is known about the biology of the species.

Eublepharis pictus sp. nov.

http://zoobank.org/6C24878A-166A-428C-AC90-834C0204FB0E

Figs 3, 4, 6; Table 2

Eublepharis hardwickii Günther 1864: 119 (in part); Boulenger 1885: 231 (in part); Boulenger 1890: 107 (in part); Smith 1935: 126 (in part); Grismer 1988:465; Mirza et al. 2014: 90 (in part)

Holotype. Adult female, NCBS NRC-AA-0015, recently dead animal recovered from a water tank near a temple in Vishakhapatnam, Andhra Pradesh, India. Collected by Gnaneshwar C. H., Rishikesh Patil, & Zeeshan A. Mirza on 4 July 2017.

Paratypes. Adult male NHMUK 1962.238, Russelconda (Ganjam District, Odisha)

Referred material. ZSIK 4121 male, Khurda, Odisha; ZSIK 23726 male, Odisha; BNHS 227 female, Jaipur, Rajasthan (likely from Jaypore, Odisha)

Diagnosis. A medium sized *Eublepharis* reaching SVL of 117 mm (max.), with 23–26 rows of large flat, tubercle-like moderately keeled scales across the dorsum intermixed with much smaller scales, a single pale band between the nuchal loop and caudal constriction; smooth subdigital lamellae on digit IV of pes 19; 17–18 precloacal pores in an angulate series lacking a diastema.

Comparison. The new species differs from all members of the genus *Eublepharis* except for *E. hardwickii* in bearing large flat, tubercle-like moderately keeled scales across the dorsum, interspaces much less than the size of the scales (vs. dorsum with small scales mixed with moderately keel to smooth rounded tubercles, interspaces much more than the size of the size of the tubercles in *E. angramainyu* Anderson & Leviton, 1966, *E. fuscus* Börner 1974, *E. macularius* (Blyth), *E. satpuraensis* Mirza, Sanap, Raju, Gawai & Ghadekar, 2014 and *E. turcmenicus* Darevsky, 1977); single pale band between the nuchal loop and caudal constriction (vs. two or more in *E. angramainyu*, *E. macularius*, *E. satpuraensis* and *E. turcmenicus*). The new species is most similar to *E. hardwickii* with which it shares several morphological traits and genetic divergence of 8–9% but differs in bearing 17 or 18 precloacal pores (vs. 16 in *E. hardwickii*), subdigital lamellae on digit IV of pes 19 (vs. 17 in *E. hardwickii*). Geographically the two species appear to be separated by the Brahmani River.

Etymology. The specific epithet '*pictus*' is a Latin word that means 'painted' referring to the colouration of the species in life. Suggested common name 'Painted leopard gecko'.

Description of holotype NCBS NRC-AA-0015. (Fig. 3): the holotype is in good condition of preservation, it is preserved in a linear manner with a curved tail. The specimen is emaciated and the vertebral column and ribs are visible as the animal likely starved to death in the water tank. The specimen does not bear any injury or any preservation artifact.

A large sized gecko (SVL 117 mm) with a fairly large head (HL/SVL ratio 0.15), head longer than wide (HW/HL ratio 0.65), head depressed (HH/HL ratio 0.65), distinct from neck (Fig. 3a, b); canthus rostralis inflated; snout short (SE/HW ratio 0.52), obtusely pointed from dorsal view and acutely in lateral view (Fig. 3c); longer than eye diameter (OD/SE ratio 0.66); scales on the snout heterogenous in shape and size, smaller ones with rounded edges and larger ones sub-hexagonal, convex; size of the scales increases in size towards the temporal region and are more flat intermixed with small rounded smooth scales. The scales post the temporal region are large, tubercle-like and sub-conical. These scales cover the dorsum of the animal, the hind limbs up-till the caudal constriction; eyes large (OD/HL ratio 0.39), pupil vertical with crenulated edges; supraciliaries 22, anterior ones smaller, these gradually increase in size and turn sub-conical from rounded towards the posterior portion. Ear-opening large, sub-oval, obliquely oriented, nearly ½ the length of the orbital diameter (EL/OD ratio 0.51) lobules absent; eye to ear distance much greater than diameter of eye (EE/OD ratio 1.37); rostral quadrangle, much wider than deep, divided by a median suture for its entire length; rostral in contact with nasal, first supralabial and internasals; two large and a much smaller (middle) internasal between nasals; nostrils large, situated medially in the nasal scale, nasal bordered by rostral, internasal, supralabial I and 8 small scales; mental sub-quadrangular, wider than long; (Fig. 3d); a pair of postmentals, in contact medially, scales bordering the postmentals and infralabials large, gradually these reduce in size on throat up till the upper thoracic region, overall these scales are circular, convex, smaller than the ones ventral aspect of trunk; supralabials ten on either sides; infralabials (to angle of jaw) eleven on left and ten on right sides.

Body elongate (TRL/SVL ratio 0.48) and dorsoventrally flattened; lacking distinct ventrolateral furrow; dorsal scalation on trunk comprises of large tubercle-like slightly depressed scales intermixed with small, round-edged scales, the large tubercle-like scales are fairly arranged in 26 longitudinal rows at mid-body, each large scale is enveloped in a rosette of 10–12 small scales; ventral scales on trunk smooth, flat, smaller than

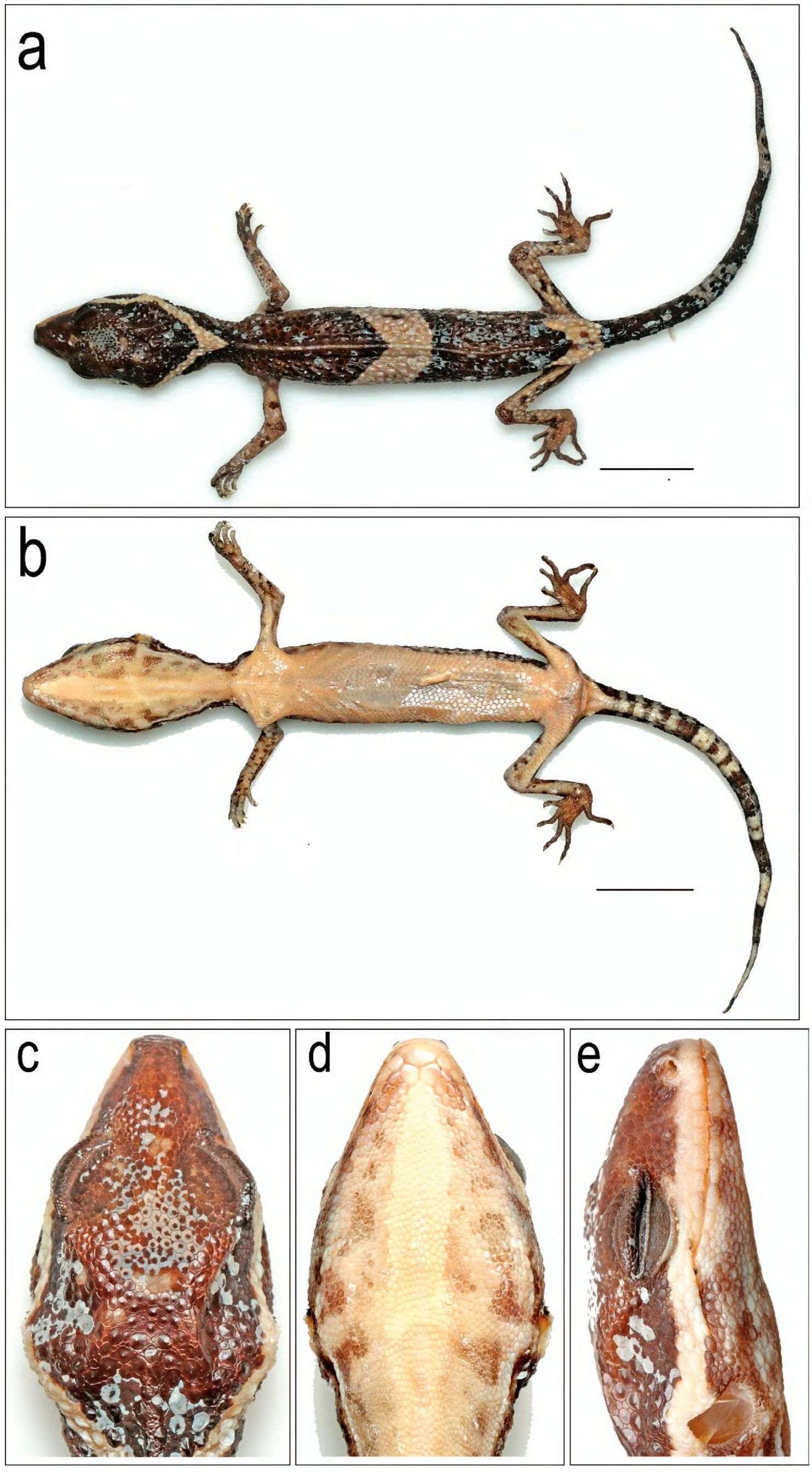

Figure 3. *Eublepharis pictus* sp. nov. holotype male NCBS NRC-AA-0015 **a.** Dorsal view; **b.** Ventral view; **c.** Head dorsal view; **d.** Head ventral view; **e.** Head lateral view. Scale bars: 20 mm.

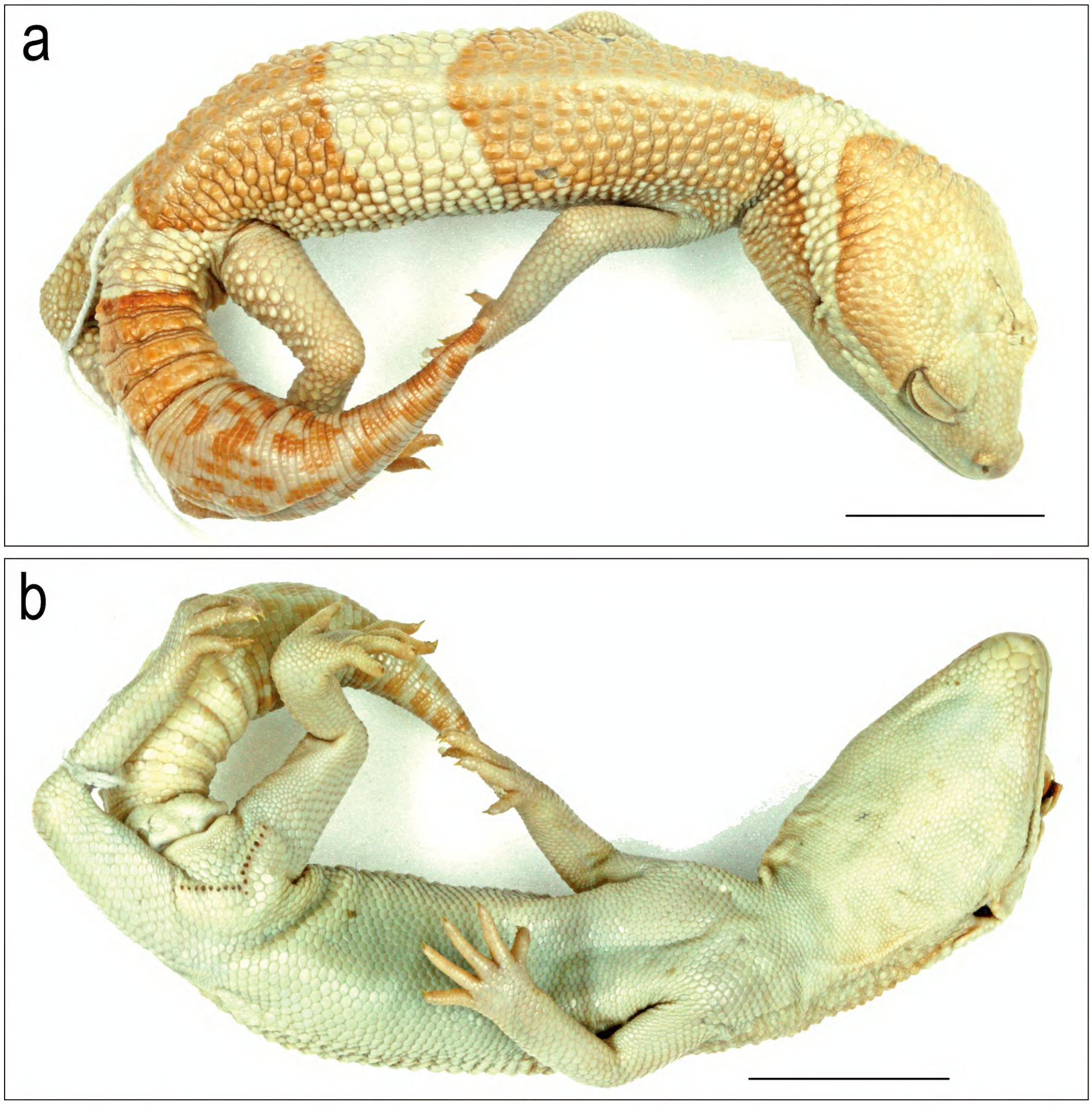

Figure 4. *Eublepharis pictus* sp. nov. paratype male NHMUK 1962.238 **a.** Dorsal view; **b.** Ventral view. Scale bars: 20 mm.

dorsal scales; mid body scales across belly 28; precloacal pores absent.

Limbs short, stout; digits dilated, bearing horizontally oriented smooth, un-notched lamellae on ventral surface; clawed, claw slightly smaller than length of the lamellar region; forelimbs short (FL/SVL ratio 0.14), equal in length with the hind limbs (CL/SVL ratio 0.14). Terminal phalanx of all digits curved, arising angularly from distal portion of expanded lamellar pad, free portion of phalanx of all digits half to more than half long as the dilated portion. Lamellae beneath the digits, right manus 7-14-14-15-12; right pes 8-16-15-19-16. Relative lengths of digits: III>V>IV>II>I (left manus), V>II>IV>III>I (left pes).

Tail stout, subtly flat on its ventral aspect, round in cross section, longer than snout-vent length (TL/SVL ratio 0.76). Caudal segments distinct on original tail,; pholidosis of original tail dorsum with small, juxtaposed scales intermixed with large sub-conical tubercles in a whorl or 9–10 rows on the first segment, thereafter reduces in number on subsequent segments, scales on regenerated portion of tail heterogenous, lacking tubercles.. Ventral aspect with large, broad scales, median row of scales not enlarged. Two rounded, slightly depressed post cloacal spurs.

Variation observed in examined material. The paratype male NHMUK 1962.238 bears 18 precloacal pores, 17 in ZSIK 4121. The paratype bears two postcloacal spurs that are sub-conical not rounded as in the holotype.

Distribution and natural history (Figs 5, 6). The new species is distributed across the states of Odisha

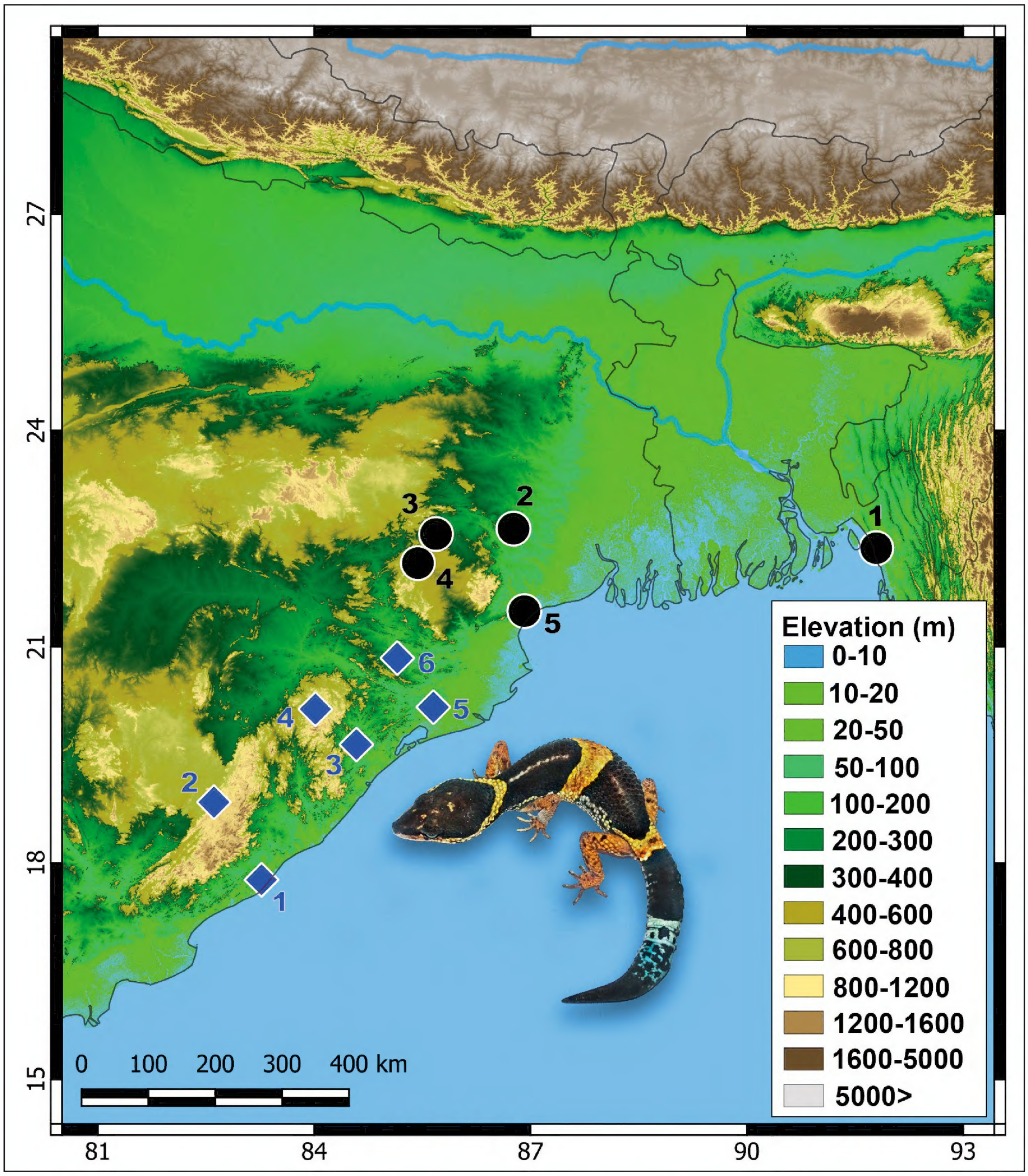

Figure 5. Map of east India showing the distribution of *E. hardwicki*i (black circles) and E. pictus sp. nov. (blue rhombus). Locality details for *E. hardwickii* (black numbers) 1. Chittagong, 2. Aushgram, 3. Chaibasa, 4. Barajamda, 5. Balasore; *E. pictus* sp. nov. (blue numbers) 1. Visakhapatnam, 2. Jaypore, 3. Kapilash, 4. Kandhamal, 5. Khurda, 6. Angul. Image of *E. pictus* sp. nov. by Gnaneshwar C. H.

and Andhra Pradesh. The forest type in the vicinity of the type locality is dry evergreen mixed with scrub and meadows. The major type of forest across Odisha where the species is found is classified as Tropical Dry Deciduous and Tropical Semi-evergreen forest (Champion and Seth 2005). The species is strictly nocturnal and has been observed actively foraging along trails in the forest after dusk. While foraging, the species has been observed licking surfaces as it moves, likely the tongue is used as a sensory organ like *E. satpuraensis* & *E. fuscus* (Mirza and Upadhye 2010, Mirza et al. 2014) and *Cyrtodactylus varadgirii* (Mirza et al. 2010, Sanap et al. 2011, Agarwal et al. 2016). A large individual was seen at carcasses of road-killed frogs on a road passing through a forested area on the outskirts of Vishakhapatnam. It is unclear if the lizards were attracted to the dead frogs or the insects on the carcasses. Three more individuals (Fig. 6b, uncollected) of the new species were seen along the same

Figure 6. *Eublepharis hardwickii* juvenile (uncollected) in its natural habitat. Photo by Supriya Samanta **a, b.** *Eublepharis pictus* sp. nov. in life from Visakhapatnam (uncollected). Photo by Zeeshan A. Mirza; **c.** Habitat near Visakhapatnam where *Eublepharis pictus* sp. nov. was observed (not collected). Photo by Zeeshan A. Mirza.

road (Fig. 6c) when the holotype was found. Other sympatric gekkotan species observed at the type locality are *Cyrtodactylus nebulosus* (Beddome, 1870), *Hemidactylus triedrus* (Daudin, 1802) and *Hemidactylus sushilduttai* Giri, Bauer, Mohapatra, Srinivasulu & Agarwal, 2017. Nothing else is known about the biology of the species in the wild. We here refrain from providing accurate locations of the species to ensure protection from illegal collection for the pet trade.

Discussion

Phylogenetic relationships within the genus *Eublepharis* are well resolved in the recent study by Agarwal et al. (2022). In their analysis for species delimitation, the new species, *E. pictus* sp. nov. was recovered as a distinct species through different criteria of species delimitation using molecular data, mPTP, PTP, bPTP and sequence divergence (Agarwal et al. 2022). The new species shows an uncorrected pairwise sequence divergence of 8–9% from *E. hardwickii* s. s. and 22–31% from congeners (Suppl. material 1: Table S1). Intraspecific sequence divergence observed is 0–4% (n = 4).

The Eastern Ghats are a broken chain of low elevation hills running from northern Odisha through parts of Jharkhand, Chhattisgarh, Telangana, Andhra Pradesh and Tamil Nadu (Mani 1974). These hills are relatively dry compared to the Western Ghats and are generally considered less biodiverse. However, these hills are home to distinct lineages across taxa, which are endemic to this region (Agarwal 2013, Datta-Roy et al. 2013, Gower et al. 2016). Molecular data for *Cyrtodactylus* (*Geckoella*) (Agarwal and Karanth 2015) and *Hemidactylus* (Giri et al. 2017, Mirza et al. 2017) form the northern part of the Eastern Ghats distributed in close proximity but show

deep divergence. A similar case is seen between *Eublepharis hardwickii* and *E. pictus* sp. nov. where the two species currently are distributed across the parts of the Chota Nagpur Plateau through the northern Eastern Ghats separated by the Brahmani River. Additional sampling in the region will be necessary to establish if the river acts as a barrier for gene flow for these two species.

The new species appears to be widespread across the state of Odisha and northern Andhra Pradesh; however, the species occurs outside protected areas. Most leopard geckos are killed when encountered (Mirza and Upadhye 2010, Das et al. 2019) and awareness about the species being harmless would be beneficial for the species. Based on IUCN conservation prioritization criteria we propose to list *E. pictus* sp. nov. and *E. hardwickii* as Near Threatened (NT) pending further information on local population estimates, especially in protected areas. The species is collected for the pet trade and even now may be smuggled illegally. Its listing as Near Threatened may contribute in minimizing the illegal trade.

Discovery of yet another species from this region warrants dedicated surveys of this region and efforts to safeguard remaining relic forests from fragmentation. The Eastern Ghats are severely under-surveyed (Javed et al. 2011, Mirza et al. 2019, Gowande et al. 2020), and dedicated efforts will help recognize it as a biodiversity hotspot.

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References

Agarwal (2013) The first teresomatan caecilian (Amphibia, Gymnophiona) from the Eastern Ghats of India. Gegeneophis. Zootaxa 3696 (4): 534–546. https://doi.org/10.11646/zootaxa.3693.4.7

Agarwal I, Bauer AM, Gamble T, Giri VB, Jablonski D, Khandekar A, Mohapatra PP, Masroor R, Mishra A, Ramakrishnan U (2022) The evolutionary history of an accidental model organism, the leopard gecko *Eublepharis macularius* (Squamata: Eublepharidae). Molecular Phylogenetics and Evolution 168: 107414. https://doi.org/10.1016/j.ympev.2022.107414

Agarwal I, Karanth KP (2015) A phylogeny of the only ground-dwelling radiation of *Cyrtodactylus* (Squamata, Gekkonidae): Diversification of Geckoella across peninsular India and Sri Lanka. Molecular Phylogenetics and Evolution 82: 193–199. https://doi.org/10.1016/j.ympev.2014.09.016

Agarwal I, Mirza ZA, Pal S, Maddock ST, Mishra A, Bauer AM (2016) A new species of the *Cyrtodactylus* (*Geckoella*) *collegalensis* (Beddome, 1870) complex (Squamata: Gekkonidae) from Western India. Zootaxa 4170: 339–354. https://doi.org/10.11646/zootaxa.4170.2.7

Blyth E (1854) Notices and descriptions of various reptiles, new or little known. Journal of Asiatic Society of Bengal 23: 287–302.

Börner A (1974) Ein neuer Lidgecko der Gattung *Eublepharis* Gray 1827. Miscellaneous Articles in Saurology 4: 7–14.

Börner A (1981) Third contribution to the systematics of the southwest Asian lizards of the geckonid genus *Eublepharis* Gray 1827: Further materials from the Indian subcontinent. Saurologica 3: 1–7.

Cantor T (1847) Catalogue of reptiles inhabiting the Malayan Peninsula and islands, collected or observed by Theodore Cantor, Esq., M. D. Bengal Medical Service. Journal of the Asiatic Society of Bengal 16: 607–656; 897–952; 1026–1078. [Pl. XIL–XL] https://doi.org/10.5962/bhl.title.5057

Champion H, Seth S (2005) A revised survey of the forest types of India. Natraj Publishers, Dehradun, 403 pp.

Chandra G, Chatterjee S, Datta C, Majumdar M, Nath A (1997) Occurrence of the fat tailed gecko, *Eublepharis hardwickii* Grey (Sauria: Gekkonidae) with remarks on the variation in certain taxonomic characteristics. Journal of the Bombay Natural History Society 94: 165–166.

Daniel J (2002) The Book of Indian Reptiles and Amphibians. Bombay Natural History Society & Oxford University Press, 252 pp.

Das I (1997) Resolution of the systematic status of *Eublepharis macularius fuscus* Boerner, 1981 (Eublepharidae: Sauria: Squamata). Hamadryad 22: 19–20.

Das I, Dattagupta B, Gayen NC (1998) History and catalogue of reptile types in the collection of the Zoological Survey of India. 3: 121–172.

Das U, Behera B, Behera B, Behera S, Dash A (2019) The New Record of East Indian Leopard Gecko *Eublepharis hardwckii*, Gray 1827 (Squamata: Sauria: Eublepharidae) from Lakhari Valley Wildlife Sanctuary, Gajpati District, Odisha India. Journal of Wildlife Research 4: 59–62.

Datta-Roy A, Mohapatra PP, Dutta SK, Giri VB, Veerappan D, Maddock ST, Raj P, Agarwal I, Karanth P (2013) A long-lost relic from the Eastern Ghats: Morphology, distribution and habitat of *Sepsophis punctatus* Beddome, 1870 (Squamata: Scincidae). Zootaxa 3670: 55–62.

Dutta SK, Nair MV, Mohapatra PP, Mahapatra A (2009) Amphibians and Reptiles of Similipal Biosphere Reserve. Regional Plant Resource Centre, Bhubaneswar, 174 pp.

Giri VB, Bauer AM, Mohapatra PP, Srinivasulu C, Agarwal I (2017) A new species of large-bodied, tuberculate *Hemidactylus* Oken (Squamata: Gekkonidae) from the Eastern Ghats, India. Zootaxa 4347(2): 1–15. https://doi.org/10.11646/zootaxa.4347.2.8

Gowande GG, Ganesh SR, Mirza ZA (2020) A new cryptic species of bush frog (Amphibia: Anura: *Raorchestes*) from the Southern Eastern Ghats, India. Taprobanica 09: 164–173. https://doi.org/10.47605/tapro.v9i2.229

Gower DJ, Agarwal I, Karanth KP, Datta-Roy A, Giri VB, Wilkinson M, San Mauro D (2016) The role of wet-zone fragmentation in shaping

biodiversity patterns in peninsular India: Insights from the caecilian amphibian *Gegeneophis*. Journal of Biogeography 43: 1091–1102. https://doi.org/10.1111/jbi.12710

Grismer LL (1988) Phylogeny, taxonomy, classification, and biogeography of eublepharid geckos. In: Estes R, Pregill G (Eds) Phylogenetic Relationships of the Lizard Families. Stanford Univ. Press, Stanford, California, 369–469.

Grismer LL, Wood Jr PL, Poyarkov NA, Le MD, Kraus F, Agarwal I, Oliver PM, Nguyen SN, Nguyen TQ, Karunarathna S, Welton LJ, Stuart BL, Luu VQ, Bauer AM, O'Connell KA, Quah ESH, Chan KO, Ziegler T, Ngo H, Nazarov RA, Aowphol A, Chomdej S, Suwannapoom C, Siler CD, Anuar S, Tri NV, Grismer JL (2021) Phylogenetic partitioning of the third-largest vertebrate genus in the world, *Cyrtodactylus* Gray, 1827 (Reptilia; Squamata; Gekkonidae) and its relevance to taxonomy and conservation. Vertebrate Zoology 71: 101–154. https://doi.org/10.3897/vz.71.e59307

International Commission on Zoological Nomenclature (1999) International Commission on Zoological Nomenclature International code of Zoological Nomenclature. International Trust for Zoological Nomenclature.

Javed SMM, Mirza ZA, Srinivasulu C, Murthy BHCK, Tampal F (2011) Divergent population of *Hemidactylus maculatus maculatus* Duméril Et Bibron, 1836 (Reptilia: Sauria: Gekkonidae) from the Northern Eastern Ghats, India. Russian Journal of Herpetology 18: 7–16. https://doi.org/10.11609/JoTT.o2388.1205-13

Kalyaanamoorthy S, Minh B, Wong T, Von Haeseler A, Jermiin L (2017) ModelFinder: fast model selection for accurate phylogenetic estimates. Nature methods 14: 587–589. https://doi.org/10.1038/nmeth.4285

Kumar S, Stecher G, Li M, Knyaz C, Tamura K (2018) MEGA X: Molecular Evolutionary Genetics Analysis across computing platforms. Molecular Biology and Evolution 35: 1547–1549. https://doi.org/10.1093/molbev/mst197

Mani M (1974) Ecology and biogeography in India. Mani M (Ed.) Dr. W. Junk b.v. Publishers, The Hague, The Netherlands, [I–XIX, 1–773 pp] 792 pp. https://doi.org/10.1007/978-94-010-2331-3

Minh B, Schmidt H, Chernomor O, Schrempf D, Woodhams M, von Haeseler A, Lanfear R (2020) IQ-TREE 2: New models and efficient methods for phylogenetic inference in the genomic era. Molecular Biology and Evolution 37: 1530–1534. https://doi.org/10.1093/molbev/msaa015

Mirza ZA, Warekar P, Mohapatra PP, Raju D, Patil P, Dutta SK, Pal S (2019) Endangered or an artifact of unsound taxonomy: case of the critically endangered bush frog *Philautus sanctisilvaticus* Das and Chanda, 1997. Zootaxa 4683: 563–576. https://doi.org/10.11646/zootaxa.4683.4.6

Mirza ZA, Sanap RV (2014) A new cryptic species of gecko of the genus *Hemidactylus* Oken, 1817 (Reptilia: Gekkonidae) from Southern India. Taprobanica 6: 12–20. https://doi.org/10.4038/tapro.v6i1.7056

Mirza ZA, Pal S, Sanap RV (2010) Notes on a ground gecko *Geckoella* cf. *collegalensis* Beddome, 1870. Russian Journal of Herpetology 17: 8–14.

Mirza ZA, Bhosale H, Patil R (2017) A new large species of gecko of the genus *Hemidactylus* Oken, 1817 (Reptilia: Sauria: Gekkonidae) from the Eastern Ghats, India. Comptes Rendus – Biologies 340: 531–540. https://doi.org/10.1016/j.crvi.2017.09.003

Mirza ZA, Sanap RV, Raju D, Gawai A, Ghadekar P (2014) A new species of lizard of the genus *Eublepharis* (Squamata: Eublepharidae) from India. Phyllomedusa 13: 75–90. https://doi.org/10.11606/issn.2316-9079.v13i2p75-90

Mirza ZM, Upadhye R (2010) Zur Verbreitung und Lebensweise des in Indien endemischen Lidgeckos *Eublepharis fuscus* Börner, 1981. Sauria 32: 15–23.

Murthy T, Aengals R (2008) Checklist of the reptiles of the Eastern Ghats, India. Cobra 2: 7–12.

Pal S, Mirza ZA, Dsouza P, Shanker K (2021) Diversifying on the Ark: multiple new endemic lineages of dwarf geckos from the Western Ghats provide insights into the systematics and biogeography of South Asian *Cnemaspis* (Reptilia: Squamata). Zoological Research 42: 675–691. https://doi.org/10.24272/j.issn.2095-8137.2021.074

Samanta S, Dutta A, Kumar B, Kumar K (2021) East Indian Leopard Gecko from the plateau region of West Bangal, India. Reptile Rap 213: 25–26.

Sanap R, Mirza ZA, Ullalkar KK (2011) Notizen zur Fortpflanzung und Nahrung von *Geckoella* spp. im Norden der Western Ghats von Maharashtra, Indien. Sauria 33: 47–50.

Smith MA (1935) The Fauna of British India, Including Ceylon and Burma. Reptilia and Amphibia. Vol. II. – Sauria. Taylor and Francis, London, 440 pp.

Thompson J, Higgins D, Gibson T (1994) ClustalW: improving the sensitivity of progressive multiple sequence alignment through sequence weighting, position-specific gap penalties and weight matrix choice. Nucleic Acids Research 22: 4673–4680. https://doi.org/10.1002/0471250953.bi0203s00

Tikader BK, Sharma RC (1992) Handbook of Indian Lizards. Zoological Survey of India, Calcutta, [xv +] 250 pp. [42 pls]

Uetz P, Hošek J (2021) The Reptile Database. http://www.reptile-database.org. [Available from] http://www.reptile-database.org [February 28, 2022]

Supplementary material 1

Table S1. Estimates of evolutionary divergence between sequences

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Data type: excel file
Explanation note: The number of base differences per site from between sequences are shown. The analysis involved 39 nucleotide sequences. Codon positions included were $1^{st}+2^{nd}+3^{rd}$+Noncoding. All ambiguous positions were removed for each sequence pair. There were a total of 1041 positions in the final dataset. Evolutionary analyses were conducted in MEGA5.
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